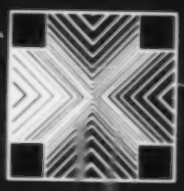

Population Trends and Public Policy Number 3 December 1981

Population Change, Resources, and the Environment

Summary—How can the world's population live in balance with resources it uses and the environment it both inhabits and shapes? In discussing this issue at a recent meeting at the Johnson Foundation Wingspread Conference Center, speakers and participants in particular noted that many important resources, most notably food, depend on the health of the natural world for their continued production. Rapid population growth intensifies the stress on this natural world, often with the consequence of increased human suffering. David Pimentel spoke about the extent of this dependence and the limits already working against expansion of the food supply. Anne Erlich listed and explained the environmental consequences of growing more food in the usual ways, with fertilizers, pesticides, irrigation, mechanization, and a reliance on crops of a single, genetically uniform strain. Stephen Schneider discussed the dilemma of fostering economic development in the Third World and the environmental consequences of that development. The use of additional fossil fuels will be worth the price in pollution, he concluded, if it buys development that lowers birth rates. For the gamble to pay off, though, it must be taken now; delay will exact an enormous price in ultimate world population size and total damage from pollution. The complexity of the problems discussed at the Conference and the overlap among subject areas—food production, energy production and use, environmental quality, family planning, economic growth—suggest the complexity of the remedies required.

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Population Trends and Public Policy, Number 4, December, 1983

Editor: Judith Jacobsen

Population Change, Resources, and the Environment

The Population Reference Bureau, Inc., recently sponsored a conference at the Johnson Foundation Wingspread Conference Center in Racine, Wisconsin. Part of a larger PRB project to inform and educate Americans about population, resources, and environmental issues, the Conference brought together 50 people from 18 states for three days of talks and discussion.

Many subjects were discussed at Wingspread—from organic farming to energy-efficient housing design to population growth rates in nineteenth-century Sweden. But a single large question drove all that was said: how can the world's population live in balance with resources it uses and the environment it both inhabits and shapes?

Population growth is a familiar topic; the "population explosion" has been in the news since the sixties. And people know a bit more now about resource scarcities—the Arab oil embargo brought that home to Americans who, unlike many in the Third World, had not since World War II had to cope with a shortage of any kind. People are also familiar with pollution and with efforts to preserve the environment. But not as many are conversant with an element of the population/resources/environment situation that received most of the attention at the Wingspread Conference: that many important resources, most notably food, depend on the health of the natural world for their continued production. Thus abusing the environment, either through overuse or contamination, affects its productivity and can in the long term reduce the resources available.

Rapid population growth intensifies environmental stresses and the environmental damage that lowers productivity, particularly agricultural productivity, often with the consequence of increased human suffering. Kingsley Davis of the Hoover Institution, Stanford, California, set the stage for the Wingspread Conference with his keynote speech on the dimensions of world population growth and the strategies needed to cope with rapid population growth. David Pimentel of Cornell University spoke about the extent of human dependence on the natural world and the limits already working against expansion of the food supply. Anne Ehrlich of Stanford University listed and explained the environmental consequences of growing more food in the usual ways, with fertilizers, pesticides, irrigation, mechanization, and a reliance on crops of a single, genetically uniform strain. Stephen Schneider of the National Center for Atmospheric Research offered a way out of the dilemma we face in choosing between economic development for the Third World and the environmental consequences of that development.

This essay draws chiefly on those presentations but also on some supporting materials. It is intended to bring current thinking about population, resource, and environmental issues as expressed at Wingspread to a wider audience than could attend the gathering.

Dimensions of Population Growth

Regardless of their respective topics, the Wingspread speakers agreed on one thing: that world population growth must be curbed as rapidly as possible. Many of the needs of the current population go unmet as it is. A larger population,

especially one that grows rapidly, will only worsen our present difficulties and may eventually make it impossible to cope at all.

Today, the world population of 4.7 billion is growing at about 1.8 percent a year, down from a peak of about 2 percent in the 1960s. Despite the slowing in growth rates, though, more people are added to the world every year than ever before because of the larger population base. As Kingsley Davis pointed out, the number of people added to the world's population every five years—365 million between 1975 and 1980—is not projected to peak until it reaches 442 million between 1995 and the year 2000 (see Figure 1).[1]

This growth takes place largely in the less developed regions—Asia, Africa, and Latin America. Indeed, 5 percent of the world's population—living in the 11 European countries listed in Table 1—are essentially at "zpg" (zero population growth). Another 20 countries, constituting nearly a fifth of the global population, are growing slowly, at under 1 percent a year. As different as Barbados and the Soviet Union, these countries all have birth rates low enough that their populations will stabilize by the next century if birth rates do not rise. Despite this, however, population increases in the large countries in this group are still substantial (see Table 2), and wealth in some of these countries makes their contributions to global resource depletion and waste disproportionate to their size.

Altogether, the more slowly growing countries account for under 10 percent of the annual increase in world population today, and this share will decline as the years go by. China, which represents over a fifth of the world's population, contributes not quite one fifth of the annual population increase today. If birth rates fall according to plan in China, population will stop growing there in the year 2000. If birth rates fall more slowly, however, which is very likely, world population growth will be greatly increased because of China's enormous size.

TABLE 1
Countries At Zero Population Growth (Natural Increase Under 0.2 Percent in 1983)

Austria	Italy
Belgium	Luxembourg
Denmark	Sweden
Germany, East	Switzerland
Germany, West	United Kingdom
Hungary	

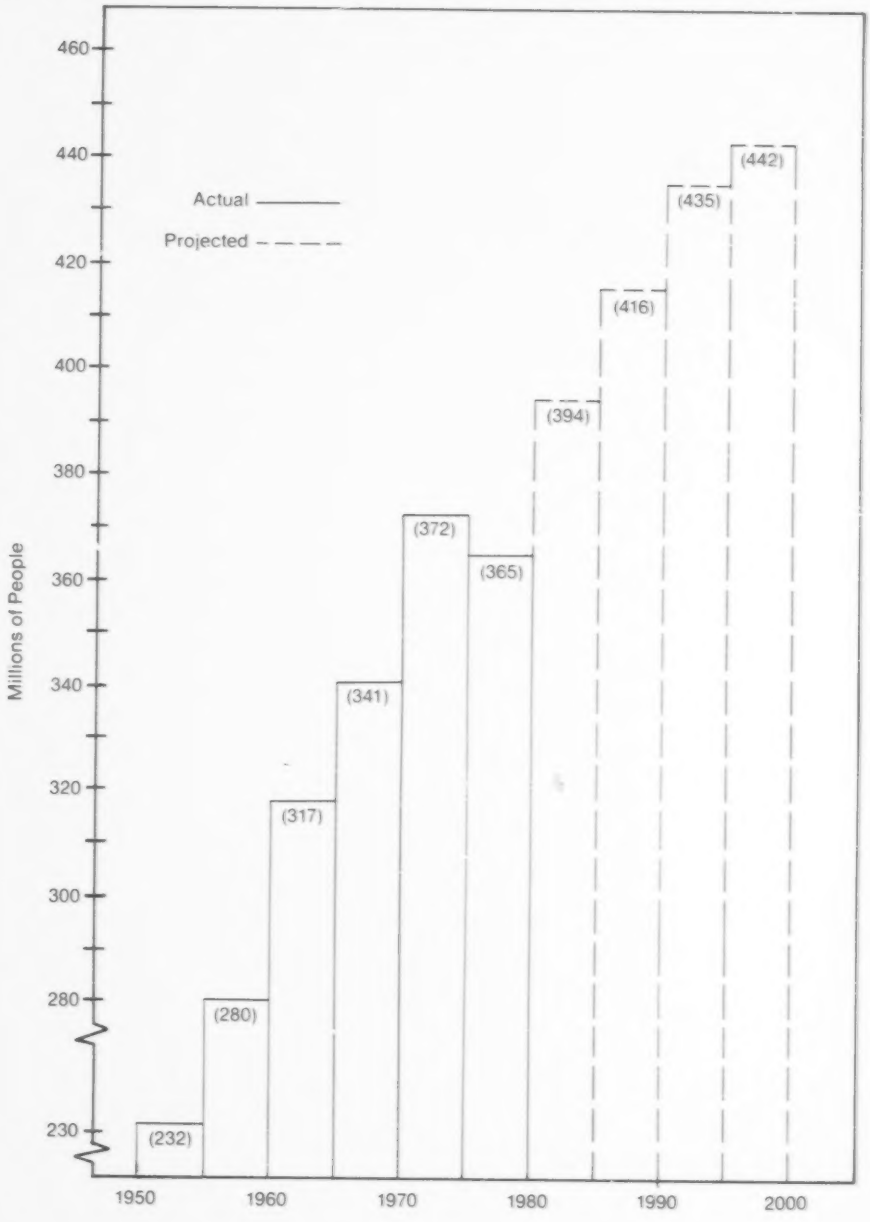
Source: Population Reference Bureau

Thus efforts to curb world population increase are most sensibly focused on the rest of the developing world, where half the world's people live but where almost three-quarters of the increase in world population today occurs. By the year 2000, these countries will contribute 77 percent of the annual population increase if the modest fertility declines projected by the United Nations materialize. Unless fertility falls very rapidly, however, most of the countries in this group will experience enormous population increases over the next few decades.

Nearly half the developing world's people and more than a third of the world's population live in countries where women on average have five or more children during their lifetimes (see Table 3). In these countries, a small fraction of couples use contraception, and birth rates have declined little if at all. The large populations of just three nations—India, Bangladesh, and Pakistan—make up more than half this group.

In countries with the highest birth rates, as many as one infant in seven dies before its first birthday, and families of eight and nine attempt to scratch a living from a few acres of overused land. Some have asserted over the years that the earth has a carrying capacity—a theoretical one—far in excess of the 4.7 billion who inhabit it today. That fact has been used to argue that population growth is not a problem. But these

Figure 1. Absolute Increase in World Population, Five-Year Intervals: 1950–2000



Sources: United Nations, Kingsley Davis

TABLE 2
Slowly Growing Countries
(Natural Increase Under 1 Percent in 1983)

Country	Annual Population Increase	Country	Annual Population Increase
Australia	138,000	Malta	2,400
Barbados	2,700	Netherlands	57,600
Bulgaria	26,700	New Zealand	25,600
Canada	199,200	Norway	12,300
Cuba	78,400	Portugal	59,400
Czechoslovakia	61,600	Romania	181,600
Finland	19,200	Spain	268,800
France	273,000	United States	1,639,400
Greece	59,400	Soviet Union	2,176,000
Japan	834,400	Yugoslavia	182,400

Source: Population Reference Bureau

theoretical arguments are cruelly irrelevant to the facts in many poor countries, the speakers agreed. Already, as Anne Ehrlich pointed out, 15 percent or more of the world's population is chronically undernourished, existing "constantly poised on the brink of starvation, vulnerable to any threat to their meager supply of food."[2] While many circumstances in addition to rapid population growth usually accompany hunger—poverty, lack of education, inadequate health care, and agricultural policies that do not encourage increases in subsistence crop production, for example—it will be difficult and costly to improve living standards of the needy among the world's current 4.7 billion; more population growth would only make an already awesome task more difficult.

Feeding Future Populations

In the year 2000, there are likely to be over six billion people in the world, and unless fertility declines are accelerated markedly in the next few years, the population will not stabilize until peaking in excess of ten billion. Just by the year 2000, if these projections materialize, there would be 45 percent more people in the Third World outside China than there were in 1983; food production would have to increase by at least that much just to maintain current levels of inadequately distributed food supplies. To feed the peak number of people in the world, annual global food production would have to be two to three times today's.[3] But there are physical, political, and financial reasons why such an increase is not assured, despite the unprecedented growth in food production that the world as a whole has enjoyed since World War II. Indeed, the very reasons for past successes in some parts of the world stand in the way of successes elsewhere.

Short-Term Obstacles: In 1950, it took a quarter of a hectare to grow the 248 kilograms of grain per person that was produced worldwide. By 1982, the world's farmers were growing 30 percent more than that per person and using only one- to two-tenths of a hectare to do it. Fertilizer, irrigation, mechanization, and pesti-

TABLE 3
Regions and Countries Where Families Average Five or More Children

Region or Country	Average Number of Children Per Family	Population (in millions)
Africa	6.5	513.0
Iraq	6.9	14.5
Saudi Arabia	7.2	10.4
Syria	7.3	9.7
North Yemen	6.8	5.7
Afghanistan	6.9	14.2
Bangladesh	6.2	96.5
Iran	6.4	42.5
Nepal	6.5	15.8
Pakistan	6.3	95.7
India	5.0	730.0
Burma	5.3	37.9
Guatemala	5.7	7.9
Haiti	5.5	5.7
Bolivia	6.6	5.9
Equador	5.7	8.8
Peru	5.0	19.2
Misc. Small Countries in Asia and Latin America	5.1-7.6	66.4
		TOTAL: 1,699.8

Source: Population Reference Bureau

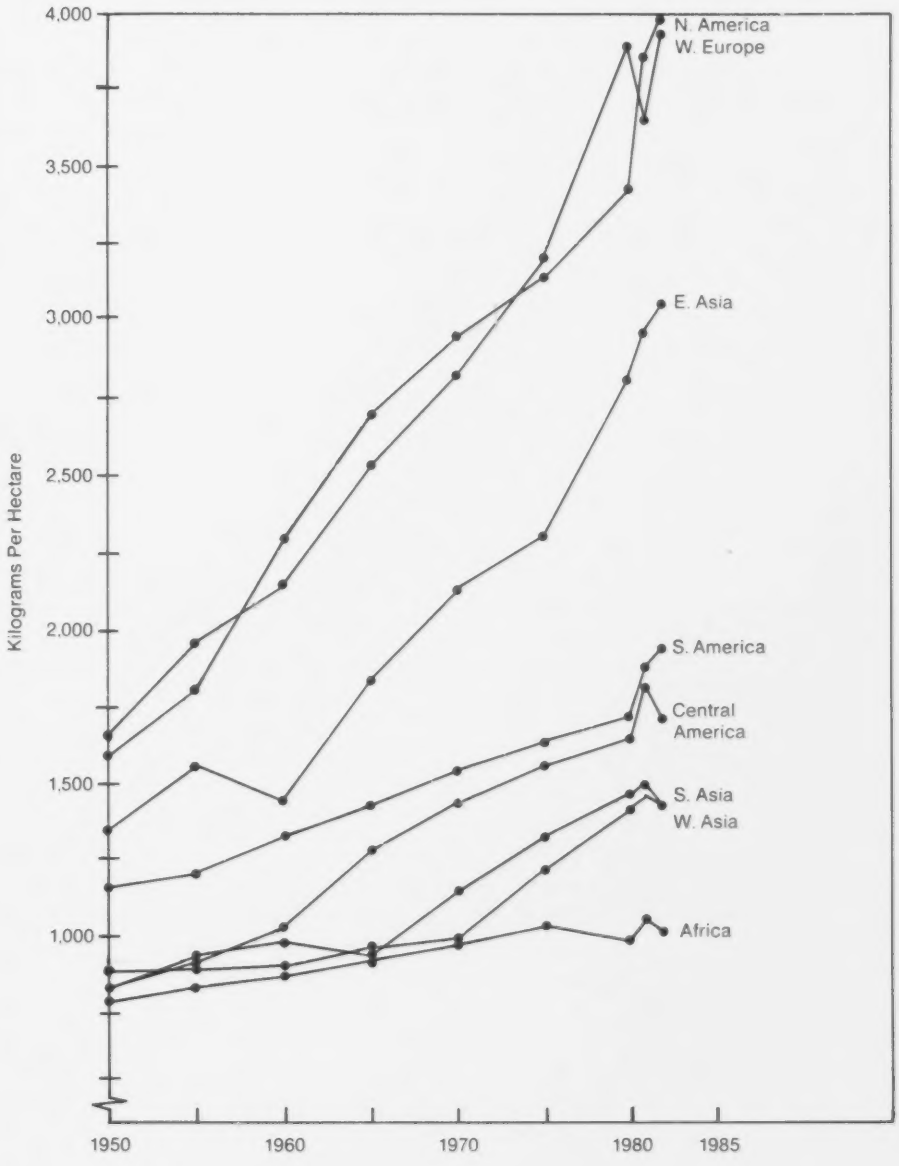
cides used with high-yielding seeds made this possible. In the 1950s and 1960s, most of the increase occurred in the developed world. The development of new, high-yielding varieties of rice, wheat, and corn in the 1970s brought higher yields to the Third World, too. This was the "Green Revolution."[4]

But the benefits of the Green Revolution did not reach everywhere. Grain yields, for example, are still low in most of the developing world compared with North America and Western Europe (see Figure 2). And the reasons the Green Revolution passed these areas by in the 1960s and 1970s stand in the way of future boosts in food production.

Some of the reasons for the failure of the Green Revolution in these areas are technical: some high-yielding varieties were not suited to local climates, for example, or fertilizers and pesticides were not available, even when farmers had the money to buy them. There were also social and political reasons, though, as Anne Ehrlich pointed out at Wingspread. Traditional farmers sometimes resisted the new seeds and farming methods, preferring instead to follow "tried and true" habits of the timing of planting and the choice of crops. Also, where agricultural policies hold down crop prices, farmers had little or no incentive to make investments that would raise production, and because much of the population of some countries is too poor to buy more food, the expanded output of farmers who used new seeds did not necessarily have a ready market.

A new and important deterrent to dramatically higher crop yields in the countries most in

Figure 2. Grain Yields, Selected Regions: 1950–1982



Source: U.S. Department of Agriculture

need of them today is the price of oil and its derivatives, which include fertilizer and pesticides. The price of gasoline, fertilizer, and pesticides deterred poor farmers from using these inputs even before the Arab oil embargo drove prices up; now, at many times the pre-1973 price, it will, if anything, *prohibit* poor farmers from using them today. Indeed, farmers in the industrialized West, wealthy by global standards, have, according to Ehrlich, "been switching to 'minimum tillage' or 'no-till' cultivation" since 1973, in part because of gasoline prices.

Where farmers cannot improve yields by adding expensive inputs, they must in future turn to additional acres to grow more food, as farmers did from the beginnings of agriculture until the modern era. But as both Ehrlich and Pimentel pointed out at Wingspread, no vast areas of productive land wait to be cultivated today; tropical regions once thought of as the agricultural frontier are found to be fragile ecosystems that require expensive inputs to grow crops for even a few years. After that, they can easily become exhausted. Other, less vast land areas that might be cropped are of lower quality than those currently planted, and their yields reflect it.

Competition for even that marginal land is heavy and is likely to intensify. Housing needs necessarily expand with a growing population—one that spreads, logically, onto farmlands that usually surround existing cities and towns. Land resources will become even more important in the future as the world turns to renewable energy as an alternative to expensive and, ultimately, scarce oil. Renewable energy technologies vary in the demand that they make on land; wind machines, solar collecters, and photovoltaic arrays are the least land-using. But raising crops such as corn or sugar cane to produce liquid fuels and damming rivers for hydropower can take enormous amounts of land—often prime farmland. Pimental said at Wingspread, for example, that at least nine times as much land is required to grow enough corn to distill into the ethanol that can fuel an average U.S. automobile for a year than is needed to feed one person.

While competition for the world's limited supply of cropland is intensifying, in the aggregate the world's farmers are experiencing diminishing returns from one of the primary substitutes for additional acres—chemical fertilizer. Pimentel cited Lester Brown of Worldwatch Institute, who has documented these trends: in the early 1950s the application of an additional ton of chemical fertilizer yielded nearly 15 additional tons of grain for the global harvest; by 1980, this figure had fallen to just under 6 tons.[5] At the Wingspread Conference, Pimentel pointed out that doubling the food supply during the next 25 years "would help offset the serious conditions of malnourishment that 500 million humans presently endure." But to do this "would require a three- to four-fold increase in the total quantity of energy (including fertilizer) expended for food production," because of diminishing returns.

The immediate barriers to expanding food production include the limited availability of agricultural land, diminishing returns from additional inputs of fertilizer and other energy-intensive materials, and the inability of the neediest farmers to make use of yield-enhancing techniques. But overcoming these technical, financial, and political barriers—"succeeding" in feeding the world—could, ironically, be a larger failure in the long run if the world's farmers accomplish the task in the same way it has been done in the recent past. Indeed, boosting the earth's carrying capacity unwisely may erode it in the long term.

Eroding Long-Term Carrying Capacity: An heir spending all of an inheritance is richer more immediately than if the inheritance is invested and the person lives indefinitely on the income earned. But the heir is poorer—poor, in fact, for all time—once the inheritance is spent.

The world faces an analogous, though much more complex, situation as it manages its agricultural resources to feed, house, and clothe its

population. In an effort to grow more, the world's farmers are using up resource endowments—their "inheritance," in effect—in two ways. First, fossil energy in the form of fertilizer and pesticides derived from oil and natural gas and in the form of fuel to power farm machinery and irrigation pumps is being used to boost production. But fossil fuel supplies will eventually be depleted, and the additional productivity these inputs yield is a temporary gain. Second, and more subtly, farming as it is practiced today can diminish long-term agricultural productivity because economic and population pressures discourage good stewardship of the land. And used improperly, high-energy inputs can exacerbate the damage to the earth's "inheritance" of fertile land.

At Wingspread, both Anne Ehrlich and David Pimentel discussed how long-term agricultural productivity is being eroded.

Soil Erosion: A primary difference between a barren planet and the fertile earth is a thin layer of broken-up rock mixed with plant and animal matter, inhabited by tiny organisms: topsoil. As it has for centuries, the earth's topsoil is washing and blowing away. This is partly inevitable: sloping fields will erode. But erosion has accelerated in recent years. Third World farmers, forced by economic and population pressures, are moving onto lands not suited for cultivation, such as steep hillsides, and they are shortening fallow periods on lands once planted to soil-holding cover for periods between crops. Farmers in the developed world—and Third World farmers with access to modern techniques—are also moving onto more erodible, marginal lands. But they accelerate erosion, too, with machines and chemicals that change soil structure and hasten its washing and blowing away.

Pimentel pointed out that in the United States today nearly 200 million acres of farmland has either been "totally ruined for crop production or has been so seriously eroded that it is only marginally suited for crop production." As much as a third of U.S. farmland is being eroded at a rate that undermines soil fertility. Fertilizers and other energy inputs have largely masked the reduction of yields that is inevitable when rich topsoil erodes, though productivity losses are being experienced on some U.S. farmlands already.

Erosion rates in the Third World are nearly double those in developed countries, according to Pimentel, and resources such as fertilizers for offsetting this degradation are not as available. In some areas, farmers are already realizing that their exhausted fields mean the "hungry season" between harvests is lengthening, as those harvests fill less of the grain bins every year.

Misuse of Irrigation: Bringing water to fertile but naturally dry farmland has contributed significantly to expanded food production around the globe since World War II. Indeed, irrigation water, along with fertilizers, pesticides, high-yield grains, and mechanization, has served as a substitute for additional cropland as farmers have succeeded in growing ever more on each acre.

But irrigation has a number of adverse consequences and, as it is practiced in many areas of the world today, cannot continue indefinitely. Irrigation from groundwater lowers the water table if it is pumped at a rate higher than that of the net natural recharge rate. Already, farmers over the Ogallala Aquifer in parts of the U.S. Great Plains have turned off irrigation pumps as the cost of pumping from so deep has exceeded the profit that could be earned from the irrigated crop.

Whether pumped from underground aquifers or diverted from rivers and streams, irrigation water can eventually damage the land it first makes more fertile, by waterlogging and salinization. As irrigation water percolates back into the ground, it can raise the water table to upper layers of the soil, becoming toxic to plants. Furthermore, evaporation from the surface deposits salt from the irrigation water in the soil, damaging fertility. At least half the world's irrigated land—15 percent of the world's cropland is irrigated—has been damaged to some degree by waterlogging or salt buildup, according to

Anne Ehrlich. Without costly correction strategies, these areas will eventually become wasteland. Some already has: Indian analysts report that "nearly seven million hectares of land have already gone out of production because of severe salinity" in India. Another quarter of the 40 million hectares of cropland currently irrigated in India "are threatened by waterlogging and salinity and are in urgent need of attention if they are not to go out of production in the near future."[6]

Altering Natural Ecosystems: Highly productive farms are essentially simplified, human-designed systems superimposed on complicated, natural ecosystems, as Anne Ehrlich pointed out at Wingspread. Rows of crops are highly artificial plant systems that depend for maximum production on fertilizer, mechanized tillage and harvesting, and protection from diseases and pests.

But this productivity comes at a price. Fertilizers and pesticides can poison in their own right, damaging fisheries, polluting water, and affecting the health of farmworkers and consumers. The use of pesticides, too, actually leads in some cases to worse pest problems in the long run, as pest populations quickly develop resistance to new pesticides. The use of large and heavy machinery can alter soil structure through compaction, but also contributes to soil erosion. As Ehrlich pointed out at the Conference, "in the United States, some soil conservation measures (such as windbreaks and contour planting) have been abandoned by farmers because they are incompatible with the use of huge machines."

Replacing a complex natural system with a simplified one also changes the natural system's effect on many things, including the atmosphere, climate, and weather; the cycling of nutrients through the environment; the processing of wastes; and the control of pests and diseases. Anne Ehrlich noted at the Wingspread Conference, for example, that deforestation—the chief cause of which is the clearing of land for agriculture around the world—typically leads to increased problems with floods and droughts in adjacent areas, reduced recharge of aquifers, and accelerated soil erosion; it probably also leads to a warmer and drier local climate. These results ordinarily follow deforestation anywhere, but they tend to be accentuated in the tropics. A similar set of problems attends desertification from overcultivation or overgrazing.

The simplification and destabilization of ecosystems caused by their conversion to agriculture is compounded by planting the cleared natural areas with single-strain crops. Indeed, "a handful of new, genetically quite uniform varieties" of the worlds's major crops—primarily wheat, rice, and corn—has replaced "hundreds to hundreds of thousands of varieties of traditionally grown strains," Ehrlich said at Wingspread. Farmers have adapted these diverse crop strains over thousands of years to local climates and soil conditions and to local pests and diseases. Planting a diversity of crops and crop varieties minimizes losses from an outbreak of pests, a crop disease, or an unfavorable change in weather. A particular disease, pest, or climatic condition to which a widely planted strain was vulnerable could wipe out that crop over very large areas. In 1970, for example, 15 percent of the U.S. corn crop was lost to a new strain of corn blight; in some areas, as much as half of the corn crop was destroyed, Ehrlich pointed out. The Irish potato famine starkly illustrates the consequences of depending on one crop: potatoes were a "Green Revolution" crop in their day for Ireland, because whole families could be fed from a single small plot of land. But in 1846, a potato blight damaged much of this sole food source for the Irish; eventually nearly two million people in Ireland starved to death.

The price, then, of highly productive farming as it is often practiced today can include soil erosion that depletes fertility; waterlogging and salinization that make it impossible to farm some acres at all; and the simplification of natural ecosystems that both depletes soil fertility and makes farming highly vulnerable to